FINAL REPORT

ACCELERATED DEVELOPMENT OF DISEASE RESISTANT LENTIL

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A. Vandenberg, A.E. Slinkard,G.G. Rowland,T. Warkentin
Crop Development Centre
University of Saskatchewan
51 Campus Drive, Saskatoon SK S7N 5A8
Ph: (306) 966-8786, 966-4978, 966-4977 and 966-2371

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DISEASE RESISTANT LENTIL

A. Vandenberg, A.E. Slinkard, G.G. Rowland and T.J. Warkentin
Crop Development Centre, University of Saskatchewan, 51 Campus Drive,
Saskatoon, SK S7N 5A8

A. PROJECT SUMMARY

This project successfully accelerated development and seed multiplication of 9 lentil varieties for the Saskatchewan pulse industry. Enough seed of CDC Milestone became available to replace production of Eston lentil in 2000. Seed of 8 additional varieties was multiplied and released to Saskatchewan Select seed growers. Large green types were CDC Glamis, CDC Grandora, CDC Sovereign, and 946-7Y. Small red varieties were CDC Robin, CDC Redcap, and 997-5. CDC Vantage is a medium green lentil. All varieties have improved resistance to ascochyta. CDC Robin has some resistance to anthracnose.

B. TECHNICAL REPORT

1. Background

Lentil (Lens culinaris Medikus) production continues to grow in western Canada. The production base grew by more than 50% between 1997 and 1999. In the year 2000, industry estimates indicate that about 1.5 million acres of lentil will be seeded in Saskatchewan. Lentil remains a valuable and profitable crop in Saskatchewan with a farm gate value of more than $250 million. Additional value arises from value-added processing (cleaning and bagging) and export of lentil. In addition, the nitrogen and non-nitrogen benefits of lentil in the rotation result in increased yield and protein concentration in the succeeding cereal crop. Several dedicated lentil decorticating and splitting plants opened in the 1997-2000 period. This added value to the crop and expanded the market for Canadian-grown lentils. Currently, Canada is the largest exporter of lentil and the cultivar Laird, an extra large-seeded type, is the standard of quality in many of the markets in Central and South America and western Europe.

Ascochyta blight, caused by the fungus Ascochyta fabae f. sp. lentis, is the most important disease of lentil in Saskatchewan, reducing yield and quality. The fungicide chlorothalonil (BRAVO 500) was registered for control of ascochyta blight in lentil in 1992. By 1996, at least 30% of the 690,000 acres of lentil in Saskatchewan were sprayed with chlorothalonil for the control of ascochyta blight. At a product cost of $11.00 per acre, this cost Saskatchewan producers about $2.5 million, even more when application and opportunity costs are included. The least costly and most environmentally benign method of plant disease control is through the use of resistant cultivars.

The Crop Development Centre (CDC) at the University of Saskatchewan has the only lentil breeding program in Canada and has developed the extra large-seeded Laird lentil (1978), the small-seeded lentil Eston (1980) and the medium large-seeded lentil CDC Richlea (1992), plus several other less common cultivars. In 1997, about 75% of the lentils grown in western Canada were Laird, whereas about 10% were Eston, 5% were CDC Richlea and 10% were other types. All of these cultivars are susceptible to ascochyta blight.

Resistance to ascochyta blight was first identified in 1987 and incorporated into the breeding program. Subsequent research identified two independent genes, each conditioning a high level of resistance to ascochyta blight. A dominant gene Ral_1 was found in ILL 5588 lentil and a recessive gene ral_2 was found in Indianhead lentil. The first two ascochyta resistant lentil cultivars were released in 1994, CDC Matador (a Spanish Brown type) with the ral_2 gene and CDC Redwing (a small-seeded, red cotyledon type) with the Ral_1 gene. CDC Matador was not accepted by the Spanish market and it has a low frequency of somatic mutations for black seed coat, further contributing to its demise. CDC Redwing became commercially successful (70,000 acres in 1998) and allowed the local decorticating and splitting industry to get started. The variety Crimson (small red with brown seed coat) was imported and allowed the red lentil industry to expand very rapidly. Crimson is not resistant to ascochyta. By 1999, the production

of Laird, Eston, CDC Richlea and Crimson (all susceptible to ascochyta blight) accounted for more than 90% of Canada's lentil production.

The dominant ascochyta resistant gene $\underline{Ral_1}$ from ILL 5588 has been incorporated into small, medium and large seed types of lentil during the course of the lentil breeding program at the CDC. The $\underline{ral_2}$ gene has been incorporated mainly into small-seeded types. Evaluation of breeding lines in local and co-operative yield trials, coupled with a winter increase program, a summer increase program, a second winter increase program, if needed, and possibly a second summer increase program can result in accelerated replacement of susceptible varieties. The release of a reasonable volume of Breeder seed of an ascochyta-resistant, Eston-type lentil, an ascochyta-resistant, CDC Richlea-type lentil and an ascochyta-resistant, Laird-type lentil within two or three years can help assure that Saskatchewan remains a low cost producer of lentil and help maintain its status as the leading lentil exporter.

2. Objectives

The primary objective of this project was to accelerate development and Breeder seed production of ascochyta-resistant lentil varieties to accelerate the replacement of varieties of (a) the Eston type (small seed size), (b) CDC Richlea type (medium seed size) and (c) Laird type (large seed size.

3. Activities and Achievements

3.1 Ascochyta-Resistant, Eston-type Lentil (Line 512-2 = CDC Milestone)

Line 512-2, an ascochyta-resistant, Eston-type lentil was entered in the 1995 and 1996 Lentil Cooperative Trials and supported for registration by the Prairie Registration Recommending Committee for Grains in February 1997. It was subsequently named CDC Milestone. In October 1996, based on its superior performance, pre-Breeder seed of CDC Milestone lentil was sent to Chile and production of 2 one-hectare Breeder seed plots was contracted ($1000/ha) with each of four Select seed growers in Saskatchewan. The small seed size of CDC Milestone lentil required a seeding rate of 30 lb/acre. This resulted in a 15-fold increase during the summer of 1997 (about 10,000 lb of Breeder seed). This was enough Breeder seed so that a further increase in Chile during the winter of 1997-98 was not warranted. This Breeder seed was allocated to Select seed growers in the spring of 1998 through the Saskatchewan Pulse Growers Variety Release Program. Sufficient seed was multiplied to plant about 200,000 acres of CDC Milestone in the spring of 2000.

CDC Milestone lentil is about 15% higher yielding than Eston. Height and maturity are similar to Eston. Seed weight is 39 g/1000 seeds, relative to 34 g/1000 seeds for Eston lentil. Seed coat colour is similar to Eston lentil but without the faint mottle. It should be an acceptable replacement for Eston lentil in the export market.

3.2 Ascochyta-Resistant, CDC Richlea-type Lentil (Line 638-23 = CDC Vantage)

Line 638-23, an ascochyta-resistant CDC Richlea-type lentil, was entered in the 1996 and 1997 Lentil Co-operative Trials and was supported for registration by the Prairie Registration Recommending Committee for Grains in February 1998. It was subsequently named CDC Vantage. In October 1996, the limited supply of available seed of CDC Vantage lentil was sent to Chile for an accelerated increase. In April 1997, about 220 lb of pre-Breeder seed arrived from Chile and production of a one-hectare pre-Breeder seed increase was contracted ($1000/ha) with each of two Select seed growers in Saskatchewan, plus a small plot was grown on the University of Saskatchewan plot land. The medium-sized seed of CDC Vantage lentil required a seeding rate of 40 lb/acre. This resulted in a 9-fold increase during the summer of 1997 (about 1200 lb of Breeder seed). Enough seed was multiplied to possibly replace CDC Richlea in the year 2001.

CDC Vantage has similar to yield potential compared to CDC Richlea, but seed quality is generally better because of its resistance to seed borne ascochyta. Maturity of CDC Vantage lentil is similar to CDC Richlea lentil, but it is slightly shorter. Seed weight is about the same as CDC Richlea lentil at about 52 g/1000 seeds. CDC Vantage lentil should be an acceptable replacement for CDC Richlea lentil in the export market since the seed coat colour is also similar.

3.3 Ascochyta-Resistant, Laird-Type Lentil (Line 578-28 = CDC Glamis)

Line 578-28, an ascochyta-resistant, Laird-type lentil, was entered in the 1996 and 1997 Lentil Co-operative Trials and was supported for registration by the Prairie Registration Recommending Committee for Grains in February 1998. It was subsequently named CDC Glamis. In October 1996, based on its superior performance in the 1996 Lentil Co-operative Trials, the limited supply of available seed of line CDC Glamis lentil was sent to Chile for an accelerated increase. In April 1997, about 200 lb of pre-Breeder seed of CDC Glamis lentil arrived from Chile and production of a one-hectare pre-Breeder seed increase was contracted ($1000/ha) with each of two Select seed growers in Saskatchewan. The large seed size of CDC Glamis lentil required a seeding rate of 60 lb/acre, so the seed increase plots were not quite one hectare in size. This resulted in a 15-fold increase during the summer of 1997 of about 3000 lbs of Breeder seed. This was an excellent seed increase ratio for a large-seeded lentil. Sufficient seed was multiplied to grow more than 20,000 acres of Registered seed in the spring of 2000. The major impact on replacing Laird will occur in 20001.

CDC Glamis lentil yields about 5% higher than Laird lentil. Maturity is similar to Laird lentil (late) and plant height is slightly shorter than Laird lentil. The seed weight of CDC Glamis lentil is 60 g/1000 seeds relative to 66 g/1000 seeds for Laird lentil. This may present a marketing problem in those countries that demand an extra large lentil.

3.4 Ascochyta-Resistant, Laird Type Lentil (Line 652=CDC Grandora)

Line 652 was tested in Cooperative Trials in 1997 and 1998 and was supported by the PRRCG in 1999. Seed of CDC Grandora was released to Saskatchewan Select growers through the SPG Variety Release Program in 1999 after Breeder seed multiplication in 1998. This cultivar has larger seed than Laird. It is about 5% higher yielding with good ascochyta resistance. It is now in seed multiplication for first commercial impact in 2001 or 2002. It is intended for the Spanish market where seed size of 7 mm or more is preferred.

3.5 Ascochyta-Resistant, Laird Type Lentil (Line 804-3=CDC Sovereign)

Line 804-3 was tested in Cooperative Trials in 1997 and 1998. It was supported by the PRRCG in 1999. Breeder seed was multiplied in 1998 and released throught the SPG Variety Release Committee in 1999 to Select growers in Saskatchewan. CDC Sovereign yields about 10% more than Laird and has good ascochyta resistance. It is slightly earlier than Laird and has plumper seed. Commercial production should begin in 2001 or 2002 depending on seed increase in the year 2000. Seed weight is similar to Laird, and seed diameter is slightly smaller.

3.6 Ascochyta-Resistant, Small Red Lentil (Line 803-18=CDC Redcap)

CDC Redcap was supported for registration by the PRRCG in 1999. It has seed coat colour similar to that of CDC Redwing, but the seed is plumper and has smaller diameter. It should be an improvement in terms of suitability for splitting. It has good ascochyta resistance, and is rated as fair for anthracnose. Pre-breeder seed was increased in Chile in the winter of 1998-99. Breeder seed was released to Select growers by the SPG Variety Release Program in 1999, and commercial impact is expected in the year 2002.

3.7 Ascochyta-Resistant, Small Red Lentil (Line 599-23=CDC Robin)

CDC Robin was supported for registration by the PRRCG in 1999. It is a small seeded red cotyledon lentil with brown seed coat colour. It is intended as a replacement for Crimson in some markets and as a new red lentil in markets such as Bangladesh where small size is preferred. CDC Robin has higher yield than CDC Redwing, and has resistance to ascochyta and anthracnose. Breeder seed was multiplied in Chile in the winter of 1998-99 for distribution through the SPG Variety Release Program in 1999. An excellent multiplication was experienced in 1999, so it is possible that commercial impact will be made in 2001.

3.8 Ascochyta-Resistant, Small Red Lentil (Line 997-5)

This line was multiplied in Chile in the winter of 1999-2000 for potential release to Select growers through the SPG-VRP in the spring of 2000. Line 997-5 combines high yield, ascochyta resistance and similar seed size and other characters compared to Crimson. It yields about 10% more than Crimson.

3.8 Ascochyta-Resistant, Laird Type Lentil (Line 946-7Y)

Line 946-7Y is the first large-seeded lentil with early maturity (possible 2 days earlier than Laird). Yield potential is more than 10% higher than Laird. Ascochyta resistance is rated as an improvement over Laird, but possibly not as good as CDC Glamis. Breeder seed was multiplied in Chile in the winter of 1999-2000 for release to Select growers.

3.9 Other Research and Development Related to Disease Resistant Lentil

During this project, a concerted effort was made to "fast-track" disease resistant varieties as a way to improve and maintain the competitiveness of the Canadian lentil industry. Extra effort was put into multi-location screening trials, Cooperative Trial management and development of additional field and laboratory tools for the eventual employment of molecular marker assisted selection in the breeding program.

This particular project was also an unqualified success from the standpoint of developing a new variety release system within the Saskatchewan pulse crop industry. The ability to release large quantities of Breeder seed of improved varieties in a short time frame has boosted the confidence of pulse growers and allowed them to become active participants in the development and commercialization of new pulse germplasm.

4. Results and Conclusions

This project showed that it is possible, through a concerted industry wide effort, to rapidly expand seed production so that new varieties with clear improvements such as disease resistance. The ability to successfully implement a production strategy of this scale and scope is a fundamental factor in maintaining the competitiveness of the lentil sector of the Canadian pulse industry. Competing production regions are mostly in Mediterranean climatic regions where seed multiplication of this size and scale are much more difficult to manage.

Seed multiplication of 3 previously identified lentil varieties (CDC Milestone, CDC Vantage and CDC Glamis) was accomplished. Identification and multiplication of 6 additional varieties was also successfully undertaken.

5. Indications for Further Development

Aggressive development of new varieties and new market classes have a dynamic effect on the lentil industry, allowing growers and exporters to respond to market conditions much more quickly than their competitors. Further development of new varieties in all market classes could also be focused on specific agro-ecological zones within Saskatchewan. In this way, producers in the Brown, Dark Brown, and Black soil zones would be able to choose varieties with specific adaptation for specific weather patterns. For instance, it may be possible to develop varieties specifically for late-seeded conditions (up to June 15). As an example, the Canadian lentil industry would be able to maintain export capability be developing the ability

respond to market conditions right up to the harvest period for Middle East producers, and after the planting period for Australian producers of red lentil.

6. Increased Market Share and Exports

The outputs of this project have a direct impact on the ability of the Canadian lentil industry to retain its position as the number one exporter of green lentil, and the possibility of becoming the number one exporter (and splitter) of red lentils.

7. Impact on Diversification

Rapid deployment of new lentil varieties with disease resistance reduces the cost of production and increases the potential for new growers to diversify into lentil production. Disease resistant varieties will require less fungicide and will have less production combined with better average seed quality in the case of ascochyta blight of lentil. Lower production costs will help Canada maintain its relative production advantage, increase market share, and increase rural employment through investment in new processing facilities, including lentil splitting. As an example, Turkish lentil splitting companies are seriously considering the possibility of investing in western Canada as a base for maintaining market share in the global red lentil market.

C. PERSONNEL

Technical assistance for plot and laboratory work.

D. EQUIPMENT

None purchased.
Growth room space rented.
Pre-Breeder seed and Breeder seed production contracted.

E. PHOTOS

None.

F. AFIF ACKNOWLEDGEMENT

AFIF support was acknowledged at all extension and research meetings on new varieties at which CDC pulse breeding personnel were asked to participate.

G. PROJECT PUBLIC INFORMATION

Information on new varieties was published through all existing seed industry channels.

H. EXPENSE STATEMENT

Provided by the University of Saskatchewan

I. DELIVERABLES

Breeder seed of the following lentil varieties: CDC Milestone, CDC Vantage, CDC Glamis, CDC Sovereign, CDC Grandora, CDC Redcap, CDC Robin, 997-5 and 946-7Y.